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Vol. VIII LANCASTER, PA., DECEMBER, 1917 No. 4

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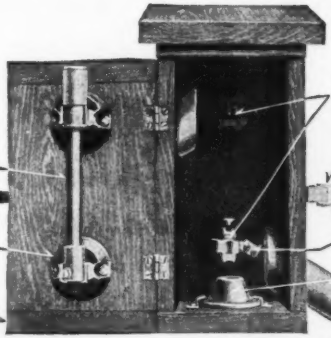
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OF THE

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THE ENGINEERING SCHOOL AND THE WAR.*

BY A. F. BARNES,

Dean, Engineering School, New Mexico A. & M. College.

In bringing this subject before you as the first presidential address of this Society, I want to say that I have had but little time to work on it, for not until the directors' meeting of October 6 was it decided to have this address. I believe it is an excellent plan, and I am anticipating with considerable pleasure the opportunity to listen to a much better paper next year from the new President soon to be elected.

As to the subject, "The Engineering School and the War," it is a vital one, and, as you will note, the title does not restrict my endeavors to a particular effect of the conflict on our schools. I purposely selected a general title, for so many questions are arising, and will continue to arise, relative to this matter that it seemed best to attempt to cover in a general manner the more important phases of the question than to treat a single aspect in an exhaustive way. As the war continues, both the engineer and the engineering school will face new problems, and no doubt many of my present impressions will be entirely changed a year from now. It will be necessary in treating this subject to touch upon industrial conditions and the standing of the engineer in America today and after the war. For only in this way may technical courses be kept abreast of the new conditions of industry.

Manufacturing and industry in America developed in the form of small shops and plants, and in our early history the

* The Editor is desirous of securing, for publication in ENGINEERING EDUCATION, articles on the effect of the war upon the engineering schools. In publishing in this number the presidential address of Dean A. F. Barnes before the Southwestern Society of Engineers, we are presenting one phase of this subject.

demand for trained engineers did not warrant educational direction along this line. In spite of many difficulties, manufacturing increased and the natural resources of this country were gradually developed until in the early years of the nineteenth century it became more and more difficult to secure skilled labor. This brought about, in the year 1823, an agitation for the founding of so-called "industrial schools." The result of this was the birth of the Rensselaer Polytechnic Institute and the Franklin Institute. From 1825 to 1860 our natural resources and industries developed very fast, and engineering was greatly stimulated by the building of canals and railroads and the invention of such important things as the McCormick reaper, the telegraph, and the sewing machine. Every new invention seemed to intensify the demand for greater knowledge of science and its application. This demand became so great that in 1857 it could be denied no longer, and the Morrill Bill was introduced into Congress, and passed in 1862. This was the foundation and is still the backbone of engineering education today. I should mention that about this time there were established, notably in the larger centers of population, privately endowed schools specializing on what was then called "practical education." It is worthy of note that the engineering schools were founded by college professors who saw the need of such training and in the face of bitter opposition on the part of their more conservative colleagues, who even went so far as to encourage students preparing for the learned professions to look on their more practical classmates as beneath them. The achievements of engineering have, however, brought about the recognition of the fact that knowledge of practical arts is essential to the education of every American.

During the past fifty years, engineering and industry have gone forward by leaps and bounds, the small shops have become the great factories of our Eastern cities, the demand for men has increased so fast that the engineering schools have had unusual growth, and today the engineering college of 700

to 800 students is not unusual. With this rapid growth of industry came the requirement of specialists in the several branches, and to meet this, highly specialized courses have been developed. The kind of man to meet this industrial need has been largely what I choose to call a producing type—a man who can do things and bring about immediate results, but, I fear, in many cases, not thoroughly grounded in the fundamental sciences. Further, until recent years there has been no general recognition of the necessity for training in the problems of organization and management. It should be noted here that the larger organizations have developed industrial research laboratories, conducted in the most cases by experts of long service with the company, and but few young men have taken up this work. The smaller companies have had to be content with what research assistance they were able to engage in a consulting capacity, in order to overcome difficulties beyond them.

What has happened to American industries since the outbreak of the European War, as affects engineering education?

1. Many industries, both large and small, have been nearly paralyzed by the lack of certain raw materials previously imported from Europe, together with increased requirements of greater quantities of others, to meet the unprecedented needs of manufacturing war implements for the belligerents.

2. This country has felt the shortage of certain finished products which were formerly imported. This has brought about attempts at manufacture of new products, by many concerns.

3. The great demand for munitions has developed a mammoth new industry. This unusual activity has created a need for a large number of engineers of two classes: (1) a research type, and (2) an executive type.

I would mention here that in only a small percentage of engineering schools has research been systematically conducted, and that the introducing of courses looking toward the training of men to enter organization work has only been carried

out in the last few years. Further examination will show that the faculties of these schools are not generally familiar with the requirements of research and organization.

During all this time the engineer has been content to take a back seat in civic life and has been too well satisfied with the praise of his immediate superior, leaving the occupancy of state and municipal offices to the politician and the lawyer. With the declaration of war by this country has come the intensifying of the demand for large numbers of men qualified to fill executive and research positions. But with this unfortunate condition that our country is facing, has come the complete recognition that the engineer is the man of the hour, if not, in fact, the savior of our country. This is very evident by the formation of many special boards and commissions, the personnel of which is composed largely of engineers, and further, it is apparent by even a casual investigation of the problems of this war that the engineer must make good if we are to win.

In addition to this need of more and better engineers, patriotism and duty have caused many technical men to enter the army and navy, which has greatly increased the shortage in the industries. To offset this, the national engineering societies have taken upon themselves the gathering of complete data and the classification for service of not only their membership, but have extended it to include any engineers that may be brought to their attention. Moreover, there has been formed an engineering council, consisting of representatives of all the larger societies, which contemplates the interlocking and the interweaving of all engineering organizations in America. It meets a real need, and should do much to bring about proper consideration of the many vital questions which the engineer is preeminently fitted to solve, and will bring united action upon questions of common interest. You may be interested to know that our distinguished and honored guest, Dr. Hollis, was very active in its organization, and is now its permanent chairman.

At the outbreak of the war, federal officials quickly realized that as a supply depot of defense and to meet the need of engineers for the reconstruction period after the war, the engineering, as well as other professional schools, must be kept going and enrollment even increased, if possible. To bring this about, early in May, college presidents from all over the United States were hurriedly summoned to Washington, upon request of the Committee on Science, Engineering and Education, of the Advisory Commission of the Council of National Defense. At this conference a statement of principles was adopted, the substance of which was:

1. That all young men below the draft age should be urged to continue their education, in order to render the most effective service during the period of the war and at the trying time which will follow the war.

2. That all colleges should modify their calendar and curricula to speed up production of trained men, recommending specifically that the college carry on work continuously, dividing the year into approximately four quarters of twelve weeks each.

3. That technical students, in view of the supreme importance of applied science in the present war, would render, through the continuation of their training, more valuable and efficient service than if they enrolled in military or naval organizations.

4. That military training should be given in all schools, as provided for in the National Defense Act of June, 1916.

5. That the Bureau of Education of the Department of the Interior, and the States Relations Service of the Department of Agriculture, with the coöperation of the Committee on Science, Engineering and Education of the Advisory Commission of the Council of National Defense, should be the medium of communication between the federal government and the higher educational institutions.

This Advisory Commission has pursued vigorously the focusing of public attention upon the desirability of keeping

the higher institutions in full operation during the war, in order that the supply of trained men might not be cut off. In order to bring greater weight to bear on this fundamental question, the Committee held a three-day conference with a commission representing the Canadian universities. At this conference the depleted condition of our allies' universities and the shortage of trained men were brought out, and recommendations were formulated to prevent our country from suffering in a like manner.

The effect of this was a letter from Commissioner of Education Claxton, suggesting that college presidents should apply for exemption from military service for their promising technical students, and do all in their power to expedite the early finishing of their courses. However, this was soon followed by a second communication revoking these instructions, as it was found that there was nothing in our draft law to warrant such exemption.

The result of all of this is that the enrollment in the engineering colleges of this country is less than normal, by from 10 per cent. to 50 per cent. In a few instances normal attendance and even an increase is reported.

The larger part of this falling off is, naturally, in the senior and junior classes, statistics reported showing a loss in these classes of from 25 per cent. to 90 per cent. In some instances the entire senior class has gone. The two lower classes are more nearly normal, and an increased enrollment in the freshman class has materially offset the losses of the upper years.

That this condition is not worse is due in part to publicity efforts of the national agencies that have been mentioned, and to local forces, such as direct publicity from the engineering colleges, and the realization by parents that this is a scientific war and that their sons must be trained to meet its problems.

The result of this falling off in enrollment, together with the cry for trained men in the industrial and military world, has left only 15 out of 64 institutions from which statistics

were gathered reporting full faculties, with a total of 206 vacancies.

It is still too early yet to know definitely all changes that have come to the engineering schools, although some of the principal consequences may be outlined. For direct service, there has been established in Washington a central Intelligence Bureau, which is undertaking to put Washington officials in touch with trained men through the medium of representatives at each institution. This has brought about a complete canvass of faculty, students, and alumni, which, though in part a duplication of the work of the Engineering Council, is reaching many good men otherwise unknown.

A second service to the government is the establishing in many of the larger institutions, under government supervision, of special training schools in aëronautics, signaling, naval engineering, patrol boat-operation, automobile practice, etc.

A third service undertaken by several institutions is the attack of special research problems by members of the faculty, while in still other instances members of the faculty are acting as advisors on special questions confronting the army and navy engineers at this time.

Up to the present time, no general change has come in the curriculum of the engineering school, except as follows:

1. Many schools opened later than usual this year, in order to allow students to assist in the harvesting of crops and other food conservation work.

2. The four-quarter plan of twelve weeks each, as recommended by the Conference of College Presidents, has been adopted by several colleges, thus reducing the length of the regular four-year course to three years.

3. Military drill and military subjects have been introduced in some institutions not giving such courses heretofore, and in a number of schools already giving such work, the time devoted to it has been materially increased.

4. In other colleges, courses of a vocational nature have been established, to turn out trained workers and vocational

teachers. This is in part the outcome of the provision of the Smith-Hughes Act recently passed by Congress.

The question is, what may take place in the engineering schools if the war continues long? There is little likelihood that students will be exempted from military service, and further, there is a probability that the age of liability for draft will be lowered. It would seem, therefore, that upper classes will continue reduced in numbers, for the average age of students at graduation is well above twenty-one years. However, the necessity of keeping up the supply of trained men is so vital that, no doubt, public sentiment approving sending young men to technical schools until they reach the age of liability will help greatly to maintain normal enrollment. To what extent, it is hard to predict.

There is every indication that as the many national boards and commissions become more completely organized, they will make use of the engineering schools' facilities and laboratories to a greater extent, the two most probable ways being: (1) For special training of officers and enlisted men in the technical branches of the army, (2) the assigning of special research problems to those institutions best fitted to handle them.

Another possibility is the further introduction of vocational courses to meet the call for skilled men needed in both the industrial and military service, with the possibility of furnishing special courses for trained workers to educate them for foremen and superintendents.

As to the place of the engineer in the world at the close of hostilities, there is, I believe, but one answer, and that is, he will stand in the public eye as *the man* of the country.

Further, he must bear the burdens of the upbuilding of a broken Europe and play the principal rôle in transferring the industries of this country from a war to a peace footing. His worth will be well understood and will result in his more and more being called upon to occupy executive positions both in industrial and in public life.

The extension of foreign trade to Mexico and Latin Amer-

ican countries now just begun will offer further opportunities for him.

If not established before the end of the war, research laboratories will be started under federal aid and control. It is probable that they will be carried out in the Land Grant Colleges or other state institutions, as has already been advocated in our last Congress. These laboratories will do much not only in the solving of problems coming up in connection with national defense and welfare but will be of great assistance to the small manufacturer and will stimulate new industries. As to the large corporation, from lessons learned in this emergency, they will expand their research activities.

All of these factors will tend to modify the engineering college and broaden its field of activity.

In the curriculum itself, courses teaching duty and loyalty to government, together with military training, will hold an important place. It is also probable that the more efficient plan of conducting schools during the entire year will become permanent in many institutions.

The need of men to fill the gap between the skilled worker and the general manager will possibly bring about a new type of course in which the Cincinnati system, or plan, requiring the student to work alternate weeks, or months, in a commercial establishment will find a prominent place.

The need of greater breadth and organizing ability for executive positions both in industrial and public life will tend to increase the length of the regular four-year course. This may bring about the more general requirement of a regular college course as a prerequisite to professional engineering study, as is so commonly practised in medicine and law. Moreover, the curriculum will surely have to give more attention to the problems of management and organization.

To meet the needs of the expansion of research and from the stimulus of government support, new courses especially designed to develop the research type of mind will be introduced.

All of these things will require careful experimentation and study of the schools, but with advice, and the coöperation of the practising engineer, satisfactory solution will come, and we will turn out a better and more efficient man to practise the greatest of all professions, namely the art and science by which the natural forces and materials are utilized for the benefit of mankind.

SYMBOLS FOR MECHANICS AND HYDRAULICS.

BY JOHN T. FAIG,

Professor of Mechanical Engineering, University of Cincinnati, Chairman, Committee on the Standardization of Technical Nomenclature, Society for the Promotion of Engineering Education.

For about a year a committee of the Society for the Promotion of Engineering Education has been working upon symbols for mechanics and hydraulics in the hope of standardizing practice. Perhaps the following statement of the methods followed, and the results obtained so far, may be of interest.

Letters were sent to professors of mechanics and hydraulics who are members of the society, and to some other persons. Each letter requested the recipient to suggest the symbols that he thought should be standards in mechanics and hydraulics.

Eighteen replies were received.

13 replies were accompanied by lists of symbols;

4 replies favored a standard list, but submitted no specific suggestions;

1 reply opposed standardization of symbols by the committee.

The following submitted lists:

O. H. Basquin,	Northwestern University;
J. E. Boyd,	Ohio State University;
G. R. Chatburn,	University of Nebraska;
I. P. Church,	Cornell University;
R. L. Daugherty,	Rensselaer Polytechnic Institute;
Wm. Kent,	Montclair, N. J.;
A. L. Jenkins,	University of Cincinnati;

E. R. Maurer, University of Wisconsin;
John McGowan, University of Toronto;
E. K. Ruth, University of Cincinnati;
S. E. Slocum, University of Cincinnati;
G. S. Thompson, Rensselaer Polytechnic Institute;
E. H. Wood, Cornell University.

The suggestions made in an article in the *Engineering News-Record* of April 12, 1917, by K. Fleming, of the American Bridge Company, were also tabulated.

The symbols suggested were charted on a large sheet and tabulated, with the result given in the following list.

SUMMARY OF THE SUGGESTIONS RECEIVED, OMITTING THOSE CONCEPTS OR SYMBOLS THAT WERE SUGGESTED IN ONE LIST ONLY.

Concept.	Symbol.	Number of Lists Suggesting It.
Acceleration, angular	α	6
Acceleration due to gravity	g	11
Acceleration, linear	a	6
Area	A	8
Breadth	b	7
Center of rotation	O	3
Coefficient of friction	μ	4
	f	2
Coefficient of roughness, Kutter	n	2
Coefficients	C, c	2
Compressive stress	C	2
Constant	K	3
	c	2
Deflection of beam	y	3
	D, Δ	2
Deformation or elongation, unit	ϵ	3
	δ	2
Depth	d	9
Diameter	d	9
Diameter of shaft	D	4
Distance	s	3
	d	2
Distance of extreme fiber from neutral axis	c	5
Eccentricity of application of load	e	3

SYMBOLS FOR MECHANICS AND HYDRAULICS.

Concept.	Symbol.	Number of Lists Suggesting It.
Efficiency (hydrau., mech., vol.)	e_h, e_m, e_v	2
Energy	E	2
Energy, kinetic	$K.E.$	2
Elongation, unit deformation or	ϵ	3
	δ	2
Force	F	8
	P	3
Force, moment of	M	4
Forces, or stresses, tensile	T	2
Force or load, total	W	5
Force or load, unit	w	7
	p	5
Friction, coef. of	μ	4
	f	2
Friction factor, hydraulic	f	5
Head	H, h	9
Height	H, h	9
Horsepower	$H.P.$	4
	$h.p.$	3
Hydraulic coefficient	c	5
Hydraulic friction factor	f	5
Hydraulic radius	r	4
	R	2
Hydraulic slope	s	6
Inertia, polar moment of	J	6
Inertia, rectangular moment of	I	13
Length	L, l	11
Load, eccentricity of application of	e	3
Load, total concentrated	P	6
Load, total force or	W	5
Load, unit force or	w	7
	p	5
Mass	M, m	6
Modulus of section	S	5
	Z	3
Modulus of elasticity, Young's	E	12
Moment, bending	M	8
Moment of force	M	4
Moment of inertia, polar	J	6
Moment of inertia, rectangular	I	13
Pressure, total	P	3

SYMBOLS FOR MECHANICS AND HYDRAULICS.

Concept.	Symbol.	Number of Lists Suggesting It.
Quantity of liquid flowing	Q, q	7
	W	2
Radius	r	9
	R	4
Radius, hydraulic	r	4
	R	2
Radius of gyration	r	7
	k	5
Radius of shaft	R	4
Reactions	R	6
Resultant	R	5
Shear	S	3
	V	2
Span of beams	l	2
Stress, compressive	C	2
Stress in member, total	$S_{t,\,c,\,s}$	2
Stress, shearing	q	3
Stresses, tensile forces or	T	2
Stress, unit	$S_{t,\,c,\,s}$	3
	f	3
	p	2
Tensile forces or stresses	T	2
Thickness of any plate	t	4
Time	t	6
Torque	T	9
Velocity, angular (rad./unit of time)	ω	7
Velocity, angular (rev./unit of time)	$r.p.m.$	3
	n	3
	N	2
Velocity, linear	v	9
Volume	V	4
Weight	W	7
	G	2
Young's modulus of elasticity	E	12

The foregoing list was mimeographed and sent to about 50 professors, editors and engineers. Accompanying each mimeographed copy was a letter which stated the method followed in making the list and which requested criticisms.

Following are the names of nineteen persons who sent replies that contained criticisms and suggestions. .

L. P. Alford	Editor (New York)
F. E. Ayer	Professor (Akron)
O. H. Basquin	Professor (Northwestern)
I. P. Church	Professor (Cornell)
R. L. Daugherty	Professor (Rensselaer)
A. L. Jenkins	Professor (Cincinnati)
Wm. Kent	Engineer (Montclair, N. J.)
A. B. McDaniel	Professor (Union College)
W. T. Magruder	Professor (Ohio State)
R. C. Matthews	Professor (Tennessee)
H. F. Moore	Professor (Illinois)
R. E. Plimpton	Editor (New York)
I. D. Potter	Professor (Kansas State)
A. L. Rice	Editor (Chicago)
N. C. Ross	Engineer (Cincinnati)
E. K. Ruth	Professor (Cincinnati)
R. F. Schuchardt	Engineer (Chicago)
S. M. Woodward	Engineer (Dayton)
R. B. Woodworth	Engineer (Pittsburgh, Pa.)

The committee also received suggestions from representatives of some of the national engineering societies and from a number of prominent publishers of engineering books.

While the number of names is not large, the list is fairly representative. The editors approved heartily of the idea of a standard list and objected to all Greek letters except π; otherwise they did not care particularly what symbols were selected. This attitude was also that of most of the practising engineers. Professors went into considerable detail and had strong preferences, but differed widely in their views. Those professors who had had the largest experience in writing and whose works are best known were favorable to the list. This was exactly contrary to the expectations of the committee.

A majority of the replies approved of a standard list based on the one submitted. In the light of the suggestions received the following list was made.

SYMBOLS SUGGESTED BY THE COMMITTEE.

Concept.	Symbol.
Acceleration, angular	
Acceleration due to gravity	g
Acceleration, linear	a
Area	A
Breadth	b
Center of rotation	O
Coefficient of friction	f
Coefficients and constants	C, K
Deflection of beam	Y
Depth	d
Diameter	D
Distance passed over	s
Distance of extreme fiber from neutral axis	c
Eccentricity of application of load	e
Efficiency (hydrau., mech., vol.)	e_h, e_m, e_v
Force	F
Force, moment of	M
Friction, coefficient of	f
Head	H
Height	h
Horsepower	H_p
Hydraulic radius	R_h
Inertia, polar moment of	J
Inertia, rectangular moment of	I
Length	L
Load, eccentricity of application of	e
Mass	m
Modulus of section	Z
Modulus of elasticity, Young's	E
Moment of force	M
Moment of inertia, polar	J
Moment of inertia, rectangular	I
Quantity of liquid flowing	Q
Radius	r
Radius of gyration	k
Reactions	R

SYMBOLS FOR MECHANICS AND HYDRAULICS.

Concept.	Symbol.
Revolutions per unit of time	N
Stress, unit	S
Time	t
Torque	T
Velocity, angular	w
Velocity, linear	v
Volume	V
Weight	W
Young's modulus of elasticity	E

Previous lists of symbols have not secured wide acceptance in this country. Some lists that have been proposed by prominent writers are familiar to very few engineers. It was apparent that the chief difficulty to be overcome was not in the formation of a list of symbols, but in securing the acceptance of the list. The method followed by the committee has been to collect evidence regarding present practice and to present it. The list obtained by this method has disadvantages. The symbols composing it are not of the same order of importance. Many omissions, some of importance, occur. But it is believed to hold the nucleus of a standard list of symbols for this country, because it is composed of symbols that are in general use. Objection has been raised on the point that professors and writers, rather than engineers, have been consulted in its making. But it is the professors and writers who are largely responsible for the present chaotic situation with regard to symbols and it is only by concerted action of these that some order may be brought out of chaos. Engineers and editors appear willing to accept any list *that will be accepted generally*. The list is presented in the hope that it will assist in the evolution of a standard list. It is short. It contains no Greek letters. It is mnemonic to a considerable degree, though not by intention. It deals largely with mechanics because that branch is common to all the divisions of engineering. For those who are interested, the list is shown in slightly altered form on the following pages. Some letters, it will be observed, are unassigned.

SYMBOLS FOR MECHANICS AND HYDRAULICS.

List of Symbols Suggested by Committee.

A ..... Area.
a ..... Linear acceleration.
B
b ..... Breadth.
C ..... Constant.
c ..... Distance of extreme fiber from neutral axis.
D ..... Diameter.
d ..... Depth.
E ..... Young's modulus of elasticity.
e ..... Eccentricity of application of load.
e_h, e_m, e_v ..... Efficiency (hydraulic, mechanical, volumetric).
F ..... Force.
f ..... Coefficient of friction.
G
g ..... Acceleration due to gravity.
H ..... Head.
H_p ..... Horsepower.
h ..... Height.
I ..... Rectangular moment of inertia.
J ..... Polar moment of inertia.
K ..... Coefficient, constant.
k ..... Radius of gyration.
L ..... Length.
M ..... Moment of force or sum of moments of forces.
m ..... Mass.
N ..... Revolutions per unit of time.
n
O ..... Center of rotation.
P ..... Concentrated load.
p
Q ..... Quantity of liquid flowing in pounds.
q
R ..... Reaction.
R_h ..... Hydraulic radius.
r ..... Radius.
S_t, S_c, S_s ..... Unit stress in tension, compression, shear.
s ..... Distance passed over.
T ..... Torque.
t ..... Time.
U
u
V ..... Volume.

v ..... Linear velocity.
W ..... Weight of a body or total weight.
w ..... Angular velocity.
X
x
Y
y ..... Deflection of beam.
Z ..... Modulus of section.
z

The members of the Committee on Technical Nomenclature, S. P. E. E., are John T. Faig, Chas. Warren Hunt, E. N. Raymond and W. D. Ennis.

SOME OBSERVATIONS REGARDING THE METHODS OF TEACHING THE THEORY OF REINFORCED CONCRETE DESIGN.

BY ALLEN B. McDANIEL,

Professor of Civil Engineering, Union College, Schenectady, N. Y.

"Rule of thumb" methods are unfortunately still prevalent in the technical world. The uneducated man uses them because he does not know better while the trained man often reverts to them for ease, speed, or simplicity. It is a simple process to solve a problem in a routine, empirical manner without any mental exertion. So many engineers regard a formula as a machine into which they may insert certain data, turn the crank and secure the desired results. The results of these mechanical, slip-shod methods are irrational and inaccurate work and low professional standards.

Mental initiative, resourcefulness, and self-reliance are the qualities which distinguish the professional engineer from the technician or mechanic. At the 24th Annual Meeting of the Society for the Promotion of Engineering Education, Professor C. R. Mann, of the Carnegie Foundation and of the Joint Committee of Engineering Societies, gave a report of his investigation for the improvement of American engineering education. One of the most significant parts of this report was the statement of the result of the questionnaire as to the relative importance of the various characteristics which the engineer should possess. The replies from over six thousand engineers, teachers, executives and others gave the qualities of character, judgment, efficiency and understanding of men a rating of 75 per cent. while knowledge of fundamentals and technique were rated at 25 per cent. Professor Mann contended that the proper teaching of the subjects rated at

25 per cent. would give the desired improvement in the qualities rated at 75 per cent. The writer heartily agrees with Professor Mann in his contention and believes that the use of proper methods of instruction in the presentation of all scientific and technical subjects will develop in the student those characteristics which have been so universally agreed upon as essential to success.

The writer has previously stated before this Society his belief that all subjects should be so taught that the knowledge gained may be intelligently applied in practice. This is necessary in order that the student may thoroughly understand the fundamental principles and their application and may acquire the true professional spirit.

Throughout his technical course, especially in the subjects of mathematics, mechanics and the subsequent advanced subjects, the student has to deal with equations and formulas. He should learn that these are mathematical expressions for definite scientific relations. He should be taught to regard these expressions as tools, as a means to an end and not an end in themselves. The student is inclined to use equations as mere abstract expressions and with no understanding of their significance or limitations. Especially is this true in the derivation and use of equations in subjects of an advanced technical nature and which apply the principles of the fundamental courses in mathematics and mechanics. An advanced subject of this nature is the theory of reinforced concrete design.

Let us consider the method of presentation of the theory of the simple rectangular beam in reinforced concrete construction. In a well-known text-book on reinforced concrete construction, the author works out eight formulas which give the relations between the percentage of reinforcement and the area of the steel and the area of the cross-section of the beam, the percentage of reinforcement and the unit safe working-fiber stresses of the steel and the concrete, the proportionate distances from the compression surface to the neutral axis and

the percentage of steel and the ratio between the moduli of elasticity of the steel and the concrete, etc.

These formulas are followed by a series of illustrative problems.

The formulas which are collected and presented for use are as follows:

$$p = \frac{a_s}{bd},$$

$$p = \frac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)}, \tag{4}$$

$$k = \sqrt{2pn + (pn)^2} - pn, \tag{5}$$

$$M_c = \tfrac{1}{2} f_c k j (bd^2) \quad or \quad bd^2 = \frac{M}{\frac{1}{2} f_c k j}, \tag{6}$$

$$M_s = p f_s j (bd^2) \quad or \quad bd^2 = \frac{M}{p f_s j}, \tag{7}$$

$$f_c = \frac{2 f_s p}{k}, \tag{8}$$

What will be the resisting moment (M) for a beam whose breadth (b) is 8 in. with a distance from the center of the reinforcement to the compression surface (d) of 12 in., the area of steel section being 0.96 sq. in.? $E_s = 30{,}000{,}000$. $E_c = 2{,}500{,}000$. $f_c = 500$ lb. per square inch. $f_s = 16{,}000$ lb. per sq. inch.

$$n = \frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}500{,}000} = 12.$$

$$p = \frac{a_s}{bd} = \frac{0.96}{(8)(12)} = 0.01.$$

From equation (5)

$$k = \sqrt{(2)(0.01)(12) + (0.01)^2(12)^2} - (0.01)(12).$$
$$= .384.$$

From equation (6)

$$M_c = \tfrac{1}{2}(500)(0.384)(0.872)(8)(12)^2$$
$$= 96{,}500 \text{ in.-lb.}$$

From equation (7)

$$M_s = (0.01)(16{,}000)(0.872)(8)(12)^2$$
$$= 160{,}700 \text{ in.-lb.}$$

M_c is the lesser of the two resisting moments and hence, controls in the design = 96,500 in.-lb.

Suppose that the beam of the preceding problem is 14 in. deep and is subjected to a bending moment of 130,000 in.-lb. Compute the greatest unit stresses in the steel and concrete.

$$p = \frac{a_s}{bd} = \frac{0.96}{(8)(14)} = 0.0086.$$

From equation (5)

$$k = \sqrt{(2)(0.0086)(12) + (0.0086)^2(12)^2} - (0.0086)(12).$$
$$= 0.363$$

From equation (6)

$$130{,}000 = (f_c/2)(0.363)(0.879)(8)(14)^2,$$
$$f_c = 520 \text{ lb. per square inch.}$$

From equation (7)

$$130{,}000 = (0.0086)(f_s)(0.879)(8)(14)^2,$$
$$f_s = 11{,}000 \text{ lb. per square inch.}$$

The writer would suggest the following method of presenting this subject before a class.

As it is assumed in this discussion that the concrete is subjected to working loads and the unit stress in the steel is within the elastic limit and the variation of stress in the concrete is rectilinear, the following fundamental propositions of mechanics may be stated:

(*a*) Any cross-section of the beam which is a plane surface before bending will remain a plane surface after bending.

(*b*) The total internal resisting moment on any cross-section of the beam must be equal to the external bending moment at the section for equilibrium.

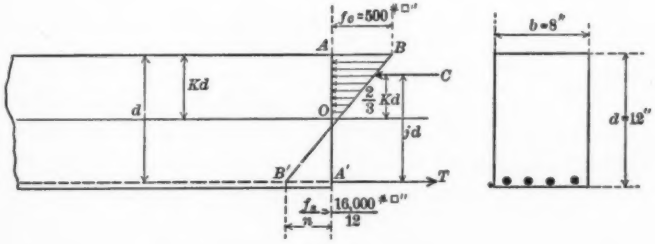
(*c*) On any cross-section of the beam, the total compressive resistance above the neutral axis must be equal to the total tensile resistance below the same axis.

With these fundamental principles in mind we will proceed with the solution of the above problems as follows:

What will be the resisting moment (M) for a beam whose breadth (b) is 8 in. with a distance from the center of the reinforcement to the compression surface (d) of 12 in., the area of steel section being 0.96 sq. in.?

$E_s = 30{,}000{,}000$, $E_c = 2{,}500{,}000$, $f_c = 500$ lb. per square inch,

$f_s = 16{,}000$ lb. per square inch.



As shown in the above drawing, let the distance from the neutral axis to the compression surface be Kd and the distance between the center of gravity of the steel and the line of action of the resultant compression be jd. The line of action of the resultant compression will be $2/3Kd$ above the neutral axis.

The total compression will be

$$\frac{500}{2} \times 8 \times 12K = 24{,}000K = C.$$

$M_c = C \times jd,$

$M_c = 24{,}000K \times 12(1-1/3K) = 288{,}000K - 96{,}000K^2.$ (1)

The total tension will be

$$16{,}000 \times 0.96 = 15{,}360 \text{ lb.} = T.$$

The moment of the tensile force will be

$$M_t = T \times jd,$$
$$M_t = 15{,}360 \times 12(1-1/3K) \quad (2)$$
$$= 184{,}320 - 61{,}440K.$$

From the figure, we can determine the value of K as follows: In the similar triangles, ABO and $A'B'O$, we have

$$\frac{AB}{A'B'} = \frac{AO}{A'O} \quad or \quad \frac{f_c}{\frac{f_s}{n}} = \frac{12K}{12(1-K)}$$

and

$$n = \frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}500{,}000} = 12.$$

Then

$$f_s = \frac{f_c(1-K)12}{K}.$$

Total compression

$$(C) = 1/2 f_c \times 12K \times 8 = 48 f_c K.$$

Total tension

$$(T) = a_s f_s = 0.96 f_s.$$

Since C must equal T,

$$48 f_c K = 0.96 f_c \frac{(1-K)12}{K}, \quad (3)$$

$$4K^2 + 0.96K - 0.96 = 0,$$

$$K = .384.$$

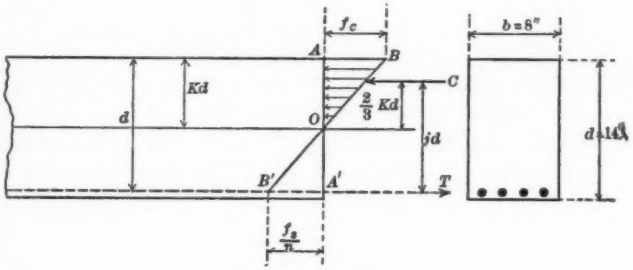
Substituting the value of K given in equation (3) in equations (1) and (2) we have:

$$M_c = 288{,}000(0.384) - 96{,}000(0.384)^2 = 96{,}440 \text{ in.-lb.}$$

$$M_t = 184{,}320 - 61{,}400(0.384) = 160{,}730 \text{ in.-lb.}$$

$M_c = 96{,}440$ in.-lb. is the lesser of the two values and hence, the resisting moment for the concrete governs the design of the beam.

Suppose that the beam of the preceding problem is 14 in. deep and is subjected to a bending moment of 130,000 in.-lb. Compute the greatest unit stresses in the steel and concrete.



Referring to the figure, we can determine the value of K as follows:

In similar triangles, ABO and $A'B'O$, we have:

$$\frac{AB}{A'B'} = \frac{AO}{A'O} \quad or \quad \frac{f_c}{\frac{f_s}{n}} = \frac{14K}{14(1-K)}$$

and

$$n = \frac{E_s}{E_c} = \frac{30{,}000{,}000}{2{,}500{,}000} = 12.$$

Then

$$f_s = \frac{f_c(1-K)12}{K}.$$

The total compression

$$(C) = 1/2 f_c \times 14K \times 8 = 56 f_c K.$$

The total tension

$$(T) = a_s f_s = 0.96 f_s.$$

Since (C) must equal (T),

$$56 f_c K = \frac{0.96 f_c (1 - K) 12}{K},$$

$$7K^2 + 1.44K - 1.44 = 0,$$

$$K = 0.363.$$

The external bending moment of 130,000 in.-lb. must be resisted by this internal moment of the concrete and of the steel.

The internal resisting moment of the concrete will be equal to the total compression (C) multiplied by its lever arm, jd.

$$M_c = C \times jd = C \times d(1\text{–}1/3K).$$

But

$$C = 1/2 f_c \times 14K \times 8 = 56 f_c K.$$

Hence

$$M_c = 56 f_c K \times d(1\text{–}1/3K).$$

$$130{,}000 = 56 f_c \times 0.363 \times 14(1 - 0.121),$$

$$250.16 f_c = 130{,}000,$$

$$f_c = 520 \text{ lb. square inch.}$$

The internal resisting moment of the steel will be equal to the total tension (T) multiplied by its lever arm, jd.

$$M_t = T \times jd = T \times d(1\text{–}1/3K).$$

But

$$T = a_s f_s = 0.96 f_s.$$

Hence

$$M_t = 0.96 f_s \times d(1-1/3K).$$

$$130{,}000 = 0.96 f_s \times 14(1-0.121).$$

$$11.81 f_s = 130{,}000,$$

$$f_s = 11{,}000 \text{ lb. per square inch.}$$

Although the second method of solving these two simple problems is a little longer than the first method, it is the rational, commonsense way; the mind of the student perceiving and understanding each step. It is thus entirely unnecessary for the student to remember formulas, all that is necessary is an understanding of a few of the simple fundamental principles of mechanics.

In the presentation of this subject, as is true of any other subject, the well-known pedagogical principles should apply. The so-called Socratic or "question and answer" method of instruction should, whenever possible, supplant the lecture system and the teacher utilize every possible device to require the student to exercise his mental processes and shun all rule-of-thumb methods.

HOW TO AWAKEN FRESHMAN INTEREST IN GOOD SPELLING.

BY A. C. F. BAEBENROTH,

Professor of English, Syracuse University.

Faulty spelling is inexcusable in an age of universal education. Yet the fact remains that most American universities feel under obligation to teach a short course in spelling for all entering students—and what is more humiliating, a long course for many of the entering class. Professor Clark, of the English department of Northwestern University, has reported that as many as sixty per cent. of a class have had to enter what is known as the "Pity-Sakes" section for deficient spellers. Employers of college graduates, with monotonous regularity report a chronic weakness in the spelling of the college men in their employ.

It is only common honesty to say at the outset that the university is not in a position to do the student real service in spelling. The nature of the regular work of the course in composition will not allow the intrusion of secondary, and certainly not of primary school work. When the writer of this article was particularly irritated a few years ago by the miserable showing of his freshmen, he compiled his spelling data and sent them to the State Education Department at Albany, N. Y. He received an answer to the effect that the department was giving increasing attention to the matter of spelling, that conditions would continue to improve, and that the college was not in a position to assume the burden which properly belonged on the shoulders of the schools below college rank.

At Syracuse University, however, the college of applied science has for many years held up a percentage of the entering

class, in spite of the increasingly good results and heightened interest revealed in the county and state spelling contests. As a result the writer has had to give a certain restricted attention to the subject of spelling, some of the results of which may be of interest to instructors who are discouraged by seeming lack of spelling progress among their technical students.

It is well first of all to impress the student with the importance of the subject. This can be done most effectively by bringing forward the question of conformity to custom, for which there is abundant illustration in everyday life. The student should come to a vivid realization of the fact that in spelling as in other matters of convention, the easiest and least troublesome road is that of conformity. Conformity eliminates friction. The way in spelling is abundantly marked, and what is more important for our present problem, easily followed by an intelligent American youth. But the proper point of view can not be aroused in the student except as the result of personal conviction.

The false notion that good spellers are born and not made should be vigorously attacked. The experience of a thoughtful teacher will provide a fund of instances where an apparently hopeless speller has been turned into a "spelling success." The writer is acquainted with a man who when a freshman absolutely refused to show interest in the subject because he had been obliged to try an examination in the secondary school twenty-three times before he succeeded in "passing." He was convinced that he was not cut out by nature to be a speller of English words. Yet the same man by the end of his college course voluntarily came into the office to confess the error of his initial contention. He was willing to agree with his instructor that many good spellers seem to be born, but that many more are made.

The personal humiliation involved in a misspelling is a potent corrective influence. No young American relishes the thought of humiliation in the eyes of one for whom he enter-

tains respect. The good-natured laugh of his fellows does not take the smart from the sting of having been caught writing such a ludicrous sentence as "This word is hack-kneed"; or "A crick runs through my father's farm"; or "The burgular alarm is not always effishent." Marshall Field, of Chicago, surely a competent authority on business, has put himself on record as saying that misspellings in a business letter are not merely irritating, but what is more, tend to shake confidence.

To the ready plea of the student that faulty spelling is due to carelessness, one can only answer that such carelessness might be forgiven were it not for the deeper implication involved, reflecting as it does on the character of the student. The underlying reason of the carelessness must be made clear to him. If his observation is careless in one direction, the inference in the mind of the majority of practical men of the world is that it will also be in others. Many a man has by poor spelling started his superiors on the road to doubt of his ability.

The philosophical basis of poor spelling, once it is recognized, will reveal the difficulty in a much more serious aspect. Far from being a matter of temperament or inheritance or both, or even of superficial carelessness, faulty spelling may be said to be the result of a fundamental lack in matters of psychology and physiology. It is a matter, the deeper implications of which involve the nervous system.

When a young man of at least average ability insists on writing "burgular," "coive," "sight" (cite), "atheletics," "Wenesday," "hack-kneed" (hackneyed), he is suffering less from poor spelling than from poor hearing and seeing and pronunciation. His optic and auricular nerves probably need the attention of a specialist. His spelling is merely an external sign of what is faulty in all the functionings of his eyes and ears.

The habit of concentration and undivided attention will produce clear-cut sense impressions. As first impressions

count for so much, it is essential that the optic nerve report the word so sharply that there need be no doubt in the future about the accuracy of the original impression. The ear must hear so keenly that there is no garbling of sounds. An ear accustomed to "cemetry" will inevitably lead the brain to signal that wrong form whenever *cemetery* is wanted. If the "g" in *recognize* is habitually elided in speech, it will as a matter of course not appear in the written form.

The young man who wishes to be enrolled in the ranks of educated persons must learn to cultivate himself if nature or his experience of life has left him with senses that do not function efficiently. Spelling appears in a more serious aspect when it is realized that for most men poor spelling is the result of senses working muddily. Infinitely more than spelling is taught when the matter is explained in this way. If a young man can be made to respect his body, the first step in the progress toward accuracy of perception has been taken. As a rule, and this applies in the vast majority of cases, bad spelling is merely an indication of a general lack in a student's nervous make-up. The alert and at the same time really efficient students are not troubled by spelling. What is meant to be conveyed is general efficiency in all branches, and activities. The point is that the senses must be kept pure. And spelling is fundamentally a matter of their proper functioning.

It is not the object of this paper to convey the impression that these suggestions will carry student and teacher all the way through the pitifully long list of words misspelled by freshmen in technical schools. Such words as *accommodation, embarrass, supersede, benefited, indispensable,* and others of a different type, depend on mnemonics of one sort or another. Etymology when sensibly used and focused on the needs of the technical student, can be made to appeal to that higher form of perception, the functioning of the imaginative faculty. The etymologies of *embarrass* and *supersede* in our

list are sufficiently vivid and concrete, if only a teacher can muster imagination enough to present them in a lively way. Furthermore, special rules for digraphs, for word accents, for prefixes, and for suffixes, will help the student to fix a difficult word in his memory. The teacher probably has a magazine of helpful suggestions for this large class of difficult spellings. But the point to be emphasized here is that for certain types of faulty spelling no suggestion will be vitally awakening and stimulating to the technical student if the underlying philosophical reason for his weakness is not brought home to him.

The good students will naturally be interested in the philosophical aspects of the explanation; whereas the bad spellers, who as a rule are skeptical about all phases of English, will wake up to the new point of view. They will be attentive because the matter of the five senses is just real and practical enough to them to bring the matter of spelling into a new focus. Practically every student I know anything about can be appealed to on the score of the purity of the senses. He will see the point at once if he is a technical student, say in forestry or engineering. My foresters especially seem to be alive to the out-of-door illustrations I use at this point to bring out the need of that keenness in touch and sight so necessary to successful woods life. It is not difficult to appeal to the engineer on somewhat similar ground, though the illustrations had better be drawn from the life of a marine engineer or from the field of civil engineering. At any rate my experience would seem to indicate that they can be most readily drawn from those sources because of the problem of adaptation necessary with freshmen.

The instructor who has never tried this method of leavening the dull mass of uninterested youth (that is, not interested in English) will be astonished at the vitalizing power of the methods suggested above. If the teacher is sure of himself, he may go on to such matters as the discrimination of *sensual*

and *sensuous,* driving home the main point not to the heart of the sermon element in the distinction, but to the core of the spelling problem which the analogy is to illuminate.

The writer has got a response where a response in the real live sense was difficult or even impossible to get by any other method. Once the student realizes the deeper implications of a weakness he has come to tolerate with a careless ease, he will be fired by a new enthusiasm for correct spelling.

REPORT OF AUDITING COMMITTEE.

NEW YORK CITY, November 5, 1917.

EXECUTIVE COMMITTEE,

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION,
UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

Gentlemen: Acting under authorization from your Committee, we have examined the books and accounts of the Treasurer of the Society for the Promotion of Engineering Education for the fiscal year ending June 21, 1917, and certify that in our opinion the funds of the Society have been fully and faithfully accounted for and are pleased to report that we found the books to be correct and in good order.

The following accounts payable at the end of the fiscal year, June 21, 1917, we herewith approve:

Dean F. L. Bishop, Secretary	$575.00
Prof. L. H. Harris, Assistant Secretary	350.00
New Era Printing Company	2,354.50
Total, Accounts Payable	$3,279.50

Respectfully submitted,

Auditing Committee,
A. H. BLANCHARD, Chairman,
C. R. MANN, per A. H. B.,
HENRY H. NORRIS.

Dues Payable June 21, 1917.

535 members owed current dues of	$2,140.00
254 members owed back dues of	1,787.22
20 Institutions owed current dues of	200.00
Total	$4,127.22

EDITORIAL.

What changes will the war make in the curricula of engineering schools? This is without doubt a question of primary importance today. It is proposed to publish in ENGINEERING EDUCATION a number of papers on this subject. The papers should develop discussion and thus tend to crystallize the subject which is now so very indefinite. Are these changes the same as those which would have developed in times of peace, and simply accelerated by the war?

The Editor believes that among others the following changes will probably develop:

(*a*) Much greater attention to the relation of the individual and his profession to the government;

(*b*) A smaller number of subjects in the curriculum;

(*c*) A greater coördination between the concrete experience of the student and the presentation of the subject;

(*d*) Placing some of the junior and senior laboratory subjects, after modification, in the earlier years and some of the mathematics and science of the first years later;

(*e*) Greater attention to the economic aspects of engineering.

Members are urged to take part in the discussion of this subject.

COLLEGE NOTES.

College of the City of New York.—To take the place of the late Professor C. H. Parmly in conducting the courses in engineering, D. B. Steinman, C.E., Ph.D. (Columbia), has been appointed professor in charge of civil and mechanical engineering. Dr. Steinman was formerly professor of civil engineering at the University of Idaho, and subsequently was assistant to the chief engineer in the design and erection of the Hell Gate arch bridge at New York City and other notable bridges. He retains his connection as a member of the firm of

Waddell & Son, consulting engineers, of Kansas City and New York.

OTHER SOCIETIES.

The Southwestern Society of Engineers held its annual meeting in El Paso, Texas, October 18 to 20 inclusive. The sessions were given over almost exclusively to army engineering; one morning session being devoted to pontoon bridge building, field surveying, fortification work and trench building at the Eighth Engineers' Camp and Ninth Engineers' Camp. The papers presented were of a military nature, the principal ones being the presidential address by Dean A. F. Barnes on "The Engineering School and the War," "The Engineer in the Present War," by Dr. Ira N. Hollis, "Some Effects of the Draft Law on the Arizona Mining Industry," by Dean G. M. Butler, and "Problems in Army Cantonment Construction," by C. A. Tilton, of Camp Cody.

BOOK REVIEWS.

Strength of Materials. By JAMES E. BOYD, M.S., Professor of Mechanics, The Ohio State University. McGraw-Hill Book Co. 1917. $6 \times 8\frac{1}{4}$, 375 pages.

The new edition of this work is much improved over the old one. It has been re-arranged to develop the subject more logically. The addition of new methods for deriving the equation of the elastic line of beams and the inclusion of a chapter on "Curved Beams" and "Hooks" make the book complete. The book covers the subject of strength of materials in an interesting and practical manner which will appeal both to instructors and students.

W. R. W.

Lubricating Engineer's Handbook. By JOHN ROME BATTLE (B.S. in M.E.). J. B. Lippincott Company. 1916 (second printing). $6\frac{1}{2} \times 9\frac{1}{4}$ cloth. 333 pages. $4 net.

This book is intended for oil salesman, purchasing agent, manager, designer, operating engineer and mechanician and it is ideal for that purpose. It is divided into five parts: Part One, Friction, Lubricants and Tests; Part Two, Miscellaneous Notes; Part Three, Bearing Lubrication; Part Four, Lubrication of Various Machines, and Part Five, Costs and Specifications. The illustrations are well chosen and the descriptions of the different problems are excellent. The work covers the field in a far greater degree than perhaps any other published work and should adequately fill the need for which it is intended.

D. D.

Electricity has leveled out the Continental Divide

Notable G-E Steam Road Electrifications

1896—Baltimore & Ohio Tunnel
1906—New York Central Terminal
1906—West Jersey & Seashore
1906—Great Northern
1910—Detroit River Tunnel
1911—Southern Pacific
1913—Butte, Anaconda & Pacific
1916—Chicago, Milwaukee & St. Paul
1917—Victorian Railways, Australia

HIGH among the bald peaks of the Montana Rockies, 6,000 feet above the sea, the high-speed, smokeless passenger trains and record-tonnage freight trains of the Chicago, Milwaukee & St. Paul wind their way up and over the Continental Divide, under electric power. These trains cross four hundred miles of the same mountain ranges that years before meant weeks of perilous travel to horseman or prairie schooner; over the same tracks where a few months before giant steam locomotives had faltered on the up-grades and heated their brakes to redness while descending.

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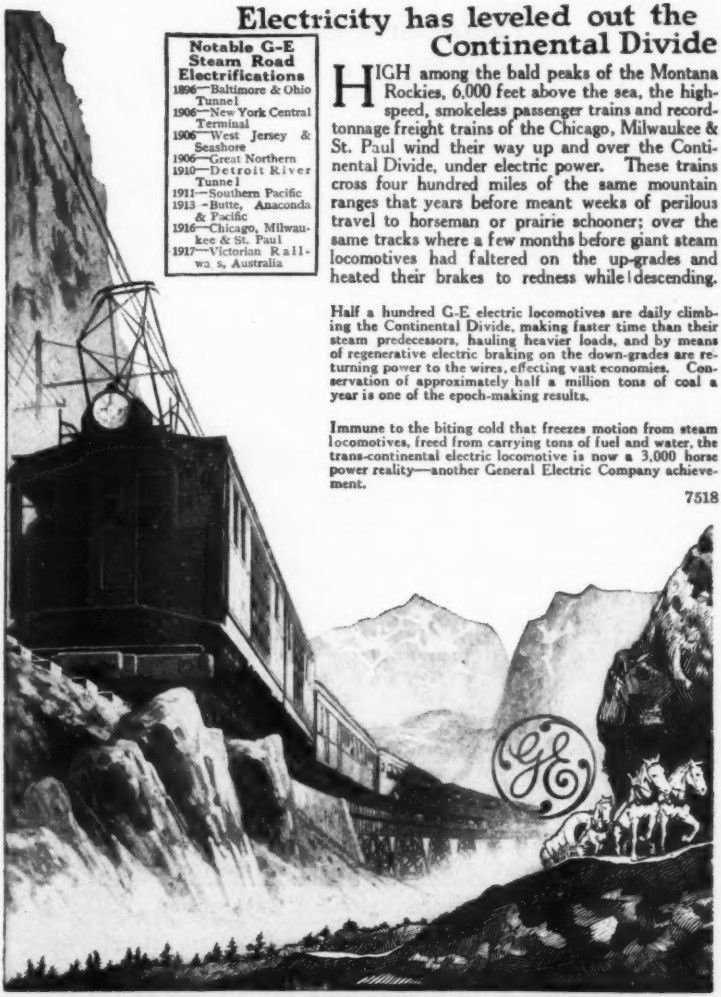

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